

What is claimed is:

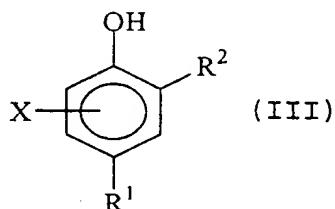
1. A method of producing a modified chitosan polymer or oligomer, which comprises reacting an enzyme with 5 at least one phenolic compound in the presence of a chitosan polymer or oligomer, wherein the reaction is carried out in a homogeneous phase solution.

2. The method of claim 1, wherein the enzyme is 10 an enzyme that uses molecular oxygen as an oxidizing agent to oxidize phenolic compounds.

3. The method of claim 2, wherein the enzyme is a 15 tyrosinase, a phenol oxidase, a polyphenol oxidase, or a mixture thereof.

4. The method of claim 1, wherein the at least one phenolic compound is phenol, a substituted phenol, a polymer having at least one phenolic moiety, a peptide having 20 at least one phenolic moiety or tyrosine residue, or a protein having at least one phenolic moiety or tyrosine residue.

5. The method of claim 4, wherein the at least one phenolic compound is a compound having the formula 25



30 wherein R<sup>1</sup> is hydrogen, hydroxyl, alkyl or substituted alkyl, alkenyl or substituted alkenyl, cycloalkyl or substituted cycloalkyl, cycloalkenyl or substituted cycloalkenyl, aryl or substituted aryl, amino or substituted amino, carboxylic acid or carboxylic acid ester, or an aldehyde or ketone group;

R<sup>2</sup> is H or OH; and

X is one or more additional substituents that can be halogen, hydroxy, alkyl or substituted alkyl, alkenyl or substituted alkenyl, cycloalkyl or substituted cycloalkyl, 5 cycloalkenyl or substituted cycloalkenyl, aryl or substituted aryl, amino or substituted amino, carboxylic acid or carboxylic acid ester, or two adjacent substituents which are joined to form a ring.

10 6. The method of claim 1, wherein the at least one phenolic compound is selected from the group consisting of phenol, 2-chlorophenol, 2,2'-dihydroxybiphenyl, 8-hydroxyquinoline, 3-amino-phenol, o-cresol, m-cresol, p-cresol, 2,3-dimethylphenol, 2-methoxyphenol, resorcinol, 1-nitrosonaphthol, hydroquinone, 4-chlorophenol, 4,4'-dihydroxybiphenyl, 2-aminophenol, 3-methoxyphenol, 1-naphthol, 4-phenylphenol, p-hydroxyphenoxyacetic acid, 5-methylresorcinol, tert-butylcatechol, catechol, methylcatechol, tyramine, dopamine, caffeic acid, 20 hydroxycinnamic acid and chlorogenic acid.

7. The method of claim 6, wherein the at least one phenolic compound is chlorogenic acid, caffeic acid, p-cresol, catechol, dopamine or a mixture thereof.

25 8. The method of claim 1 wherein the at least one phenolic compound is a mixture of phenolic compounds.

9. The method of claim 1, wherein the solution is 30 an aqueous solution or an aqueous alcohol solution.

10. The method of claim 9, wherein the solution has a pH of less than about 6.5. 113

11. The method of claim 9, wherein the solution has a pH of at least about 8. (16)

12. The method of claim 1 wherein the modified 5 chitosan polymer or oligomer is soluble in aqueous alkaline solution.

13. The method of claim 12, wherein the solution is an aqueous solution or an aqueous alcohol solution. 10

14. The method of claim 12, wherein the reaction is carried out at a pH of about 5.5 to about 6.5. (17)

15. The method of claim 12, wherein the modified 15 chitosan polymer or oligomer is soluble in aqueous alkaline solutions having a pH of at least about 8.

16. The method of claim 15, wherein the modified 20 chitosan polymer or oligomer is soluble in aqueous alkaline solutions having a pH of about 8 to about 14.

17. The method of claim 12, wherein the modified chitosan polymer or oligomer is soluble in aqueous acidic solutions. 25

18. The method of claim 12, wherein the modified chitosan polymer or oligomer is insoluble in aqueous solutions having a neutral pH.

19. The method of claim 10, wherein the modified 30 chitosan polymer or oligomer is soluble in aqueous alkaline solutions having a pH of at least about 8, soluble in aqueous acidic solutions, and insoluble in aqueous solutions having a neutral pH.

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20. The method of claim 1 wherein the modified chitosan polymer or oligomer has a high viscosity in solution.

5 21. The method of claim 20, wherein the viscosity of a solution of the modified chitosan polymer or oligomer is at least about 1 poise.

10 22. The method of claim 21, wherein the viscosity of a solution of the modified chitosan polymer is at least about 40 poise.

15 23. The method of claim 22, wherein the viscosity of a solution of the modified chitosan polymer or oligomer is at least about 400 poise.

24. A method of producing a modified chitosan polymer, which comprises:

20 (a) providing a chitosan polymer or oligomer solubilized in a solution;

(b) reacting an enzyme with at least one phenolic compound in the presence of the chitosan polymer or oligomer to produce a modified chitosan polymer or oligomer; and

25 (c) further reacting an enzyme with at least one phenolic compound in the presence of the modified chitosan polymer or oligomer to produce a further modified chitosan polymer or oligomer.

30 25. The method of claim 24, which further comprises repeating step (c) to further modify the modified chitosan polymer.

26. The method of claim 24, wherein the reaction of step (b) is carried out at a pH of about 5.5 to about 6.5.

27. The method of claim 24, wherein the reaction of step (c) is carried out at a pH greater than about 6.5.

28. The method of claim 27, wherein the reaction of step (c) is carried out at a pH of at least about 8.

29. A modified chitosan polymer or oligomer produced by the process of claim 1.

30. A modified chitosan polymer produced by the process of claim 12.

31. A modified chitosan polymer produced by the process of claim 20.

32. A modified chitosan polymer produced by the process of claim 24.

33. A modified chitosan polymer which is soluble in both acidic and basic aqueous solution.

34. A modified chitosan polymer having a viscosity of at least about 1 poise.